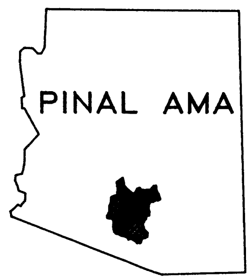
ARIZONA DEPARTMENT OF WATER RESOURCES

PINAL ACTIVE MANAGEMENT AREA
SECOND MANAGEMENT PLAN
SIMULATION OF WATER USE SCENARIOS UTILIZING
THE PINAL AMA REGIONAL GROUNDWATER FLOW MODEL



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ARIZONA DEPARTMENT OF WATER RESOURCES
PINAL ACTIVE MANAGEMENT AREA

Second Management Plan

Simulation of Water Use Scenarios
Utilizing the Pinal AMA Regional Groundwater Flow Model

Final Report

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by Frank Corkhill and Paul Plato

Groundwater Modeling Section

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Abstract

The Arizona Department of Water Resources has developed and used the Pinal Active Management Area Regional Groundwater Flow Model to simulate various Second Management Plan scenarios of future water use in the Pinal AMA through the year 2025. The scenarios explore the impacts of improved agricultural irrigation efficiencies, decreasing agricultural acreage, increasing municipal and industrial water use and increasing Indian irrigation. The scenarios analyze the effects of variable usage of Central Arizona Project surface water.

The model results demonstrate the effects of utilizing all available surface water resources while reducing agricultural acreage. The model results indicate that certain areas of the Maricopa-Stanfield sub-basin will be faced with the reduction or elimination of groundwater pumping by the year 2025.

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Chapter I. Introduction

Introduction

The Arizona Department of Water Resources (ADWR) has developed a Regional Groundwater Flow Model for the Pinal Active Management Area (AMA). The model development and calibration process is documented in the Pinal AMA Regional Groundwater Flow Model, Phase One and Phase Two reports (Wickham and Corkhill, 1989) (Corkhill and Hill, 1990). The model has been recently utilized to simulate various Second Management Plan (SMP) scenarios of future water use in the Pinal AMA (ADWR, 1991a). This report discusses the results of those model simulations.

Objective, Scope, Goals

The general objective of the model simulations is to provide quantitative estimates of the impacts of potential groundwater pumpage and surface water utilization on the groundwater system of the Pinal AMA. The scope of the simulations is limited geographically to areas within the Pinal AMA of significant water use, and temporally to the time period 1985-2025. The goal of the modeling effort is to provide useful hydrologic projections which will aid the Pinal AMA in testing and refining its groundwater management strategies. These strategies are designed to help achieve the Pinal AMA's ultimate management goal of maintaining the agricultural economy for as long as possible, while allowing development of non-irrigation water uses and preserving water supplies for future non-irrigation purposes.

Model Area

The Pinal AMA is approximately 4,000 square miles in size and includes five hydrologic sub-basins: Maricopa-Stanfield, Eloy, Vekol Valley, Santa Rosa Valley, and Aguirre Valley. The modeled area is approximately 1,100 square miles in size and is located primarily in the Maricopa-Stanfield and Eloy sub-basins (Figure 1). The modeled area was selected to encompass the areas within the Pinal AMA which currently have or will have the highest urban and agricultural development and greatest water use.

Factors Which May Effect Model Results

The model results which are presented in this report represent an informed estimate of future groundwater conditions in the Pinal AMA. However, they should not be accepted as an absolute prediction of future groundwater conditions.

The model scenarios are based on many important assumptions concerning water demand and supply, and it is probably unreasonable to assume that all of the assumptions will hold true. Several important factors may change the assumed conditions of water demand and supply. Those factors include: 1) reallocation of Central Arizona Project (CAP) supplies due to Indian water settlements, 2) reallocation of CAP supplies due to possible changes in interstate water compacts, 3) increased projected water demand if the San Carlos Irrigation Project (SCIP) canal system remains unlined, 4) changes in groundwater and surface water usage due to new rules and programs (such as, indirect recharge), 5) long-term weather changes which affect surface water availability, 6) increased recharge from Gila River flood flows which were not evaluated as a potential source of recharge due to the sporadic nature of flood events.

The model results are also affected by the ability of the model to simulate certain types of groundwater flow conditions. The groundwater flow model is only an approximate representation of the very complex groundwater flow system of the Pinal AMA, and it was necessary to make certain generalizations or simplifications in order to construct the groundwater model. It should be recognized that the model does not: 1) permit the rewetting of dewatered cells, 2) account for the effects of subsidence or, 3) simulate the Casa Grande perched system. Therefore, it is recommended that the reader view the model results in context with the underlying assumptions and limitations.

Chapter II. Modifications to the Phase Two Model

Two modifications were made to the Phase Two Pinal AMA Regional Groundwater Flow Model in conjunction with these SMP simulations (Corkhill and Hill, 1990). The modifications were made in recognition of new data and further sensitivity testing of the original Phase Two model.

The first modification consisted of reducing the horizontal hydraulic conductivity in Layer One model cells representing the channel of the Gila River. The final calibrated Phase Two values of 3,000 gpd/ft^2 were reduced to 1,250 gpd/ft^2. This modification was made in recognition of new hydraulic conductivity information provided by recent USGS modeling studies (Pool, 1991) (Thomsen and Eychaner, 1991).

The second modification consisted of multiplying the final calibrated Phase Two - Layer Two horizontal hydraulic conductivities by a factor of three. This modification was made in recognition of the sensitivity of Layer Two water levels to this parameter. Initially, the model scenarios were tested with the final calibrated Phase Two - Layer Two hydraulic conductivities. However, an analysis of the results of these model runs revealed improbable and excessive groundwater drawdowns in the areas of significant groundwater withdrawals. The implication of this observation is that the calibrated Layer Two hydraulic conductivities were probably underestimated. As a consequence, the Layer Two hydraulic conductivities were increased by a factor of three, and more probable and historic drawdown rates were obtained. The selection of the multiplication factor of three was based on recent information regarding Lower Conglomerate Unit (LCU) hydraulic conductivities in the Eloy sub-basin (Pool, 1991), and in the Salt River Valley (ADWR, 1991b). It should be noted that the underestimation of Layer Two hydraulic conductivities was primarily due to the lack of extensive hydraulic conductivity data during the original calibration.

Chapter III. Second Management Plan Scenarios

General Background

Groundwater management goals and objectives have been established for each of the AMAs under the Groundwater Management Act of 1980. The Groundwater Code directs the ADWR to develop a series of five water management plans covering the period of 1980 to 2025. The First Management Plan (FMP) was the initial step toward a comprehensive and effective water management program (ADWR, 1985). The FMP initiated conservation programs and focused attention on important water management issues.

The Second Management Plan (SMP) covers the period 1990 to 2000. The SMP not only continues the water conservation efforts of the FMP, but also establishes an overall management strategy for the 1990's which will identify water management problems and develop appropriate solutions (ADWR, 1991a). The Pinal AMA Regional Groundwater Flow Model has been developed to serve as a quantitative analytical tool which will aid the Pinal AMA in identifying present and future water management problem areas. The model also provides a means of testing future water use scenarios, and thereby provides useful predictions concerning the impacts of future water use patterns on the groundwater system of the Pinal AMA.

The future water use scenarios which are presented in this report have been developed in cooperation with the Pinal AMA. The scenarios represent a translation of generalized AMA-wide SMP projections of water demand and supply into the area-specific Pinal AMA model grid (model cells which are roughly one square mile in area). Two series of scenarios are presented in this report. Both explore the impacts of improved agricultural irrigation efficiencies, decreasing agricultural acreage, increasing municipal and industrial water use and increasing Indian irrigation. The two series differ in respect to the utilization of Central Arizona Project (CAP) water allotments. The first series, designated the Total CAP (TCAP) utilization series, simulate water use conditions under which the major irrigation districts in the AMA totally utilize their annual CAP surface water allotments. Under the TCAP series the districts supply their remaining water demand with alternative sources of surface water, if available, and with pumped groundwater. The second series, designated the Partial CAP (PCAP) utilization series, simulates water use conditions under which the major irrigation districts in the AMA pump a fixed annual volume of groundwater, and supply their remaining water demand with CAP surface water.

Model Simulation Period and Model Stress Periods

The time period simulated during the model projections begins in 1985 and extends 40 years to 2025. The hydrologic stresses of pumpage and recharge which are applied from 1985 through 1988 are based on actual water use estimates, and are the same values which were applied in the Phase Two calibration period (Corkhill and Hill, 1990). Beginning in 1989 the stress rates are based on the water use projections developed by the Pinal AMA. The projected stress rates are held constant from 1989 through 1999. In the year 2000 the stress rates change and are again held constant through 2025. The changing model stress rates reflect the anticipated improvement of non-Indian agricultural irrigation efficiencies, reduction in non-Indian cropped acreage, increase in Indian cropped acreage, reduction in San Carlos Irrigation Project canal leakage, and changing availability of CAP surface water. More detailed information concerning the model stress rates and conceptual water budgets for the model simulations are provided later in this report.

Pinal AMA - Regional Water Use Sub-areas

The Pinal AMA model area is divided into three regional water use sub-areas in this report. The purpose of this subdivision is to better define water supply and demand variables on a geographic basis. The sub-areas generally coincide with the boundaries of the major irrigation districts in the AMA (Figure 1). Area One roughly corresponds to the Maricopa-Stanfield sub-basin. Area Two corresponds to the northern half of the Eloy sub-basin, and Area Three corresponds to the southern half of the Eloy sub-basin.

The major irrigation districts and other water use entities in Area One are the Maricopa-Stanfield Irrigation and Drainage District (MSIDD), the Ak-Chin Indian Reservation, a small section of the San Carlos Irrigation and Drainage District (SCIDD), a few mini-farms and other agricultural and industrial water users who are not affiliated with irrigation districts. The major water use entities in Area Two are the SCIDD, the San Carlos Irrigation Project (SCIP) in behalf of the Gila Indian River Community, the Hohokam Irrigation and Drainage District (HIDD), and other agricultural and industrial water users who are not affiliated with irrigation districts. The major water use entities in Area Three are the Central Arizona Irrigation and Drainage District (CAIDD) and the Tohono O'odham Indian Community. The total projected agricultural acreages for each of the regional sub-areas are presented in Table One.

TABLE 1
PROJECTED AGRICULTURAL ACREAGE IN THE PINAL AMA REGIONAL WATER USE SUB-AREAS 1989-2025
(Acres)

	Area I		Area II		Area III	
Sub-Area Acreage Type	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***
100% IGFR Acreage						
Irrigation District IGFR	96,250	92,754	72,862	69,569	87,706	83,732
Non-Affiliated IGFR	5,945	5,711	15,576	14,869	506	480
Indian	16,500	16,500	16,365	22,974	5,150	5,150
Total Area Acreage	118,965	114,965	104,803	107,412	93,362	89,362
80% IGFR Acreage						
Irrigation District IGFR	77,216	74,203	58,290	55,655	70,165	66,986
Non-Affiliated IGFR	4,756	4,569	12,461	11,895	405	384
Indian	16,500	16,500	16,365	22,974	5,150	5,150
Total Area Acreage	98,472	95,272	87,115	90,524	75,720	72,520
60% IGFR Acreage						
Irrigation District IGFR	57,912	55,652	43,717	41,741	52,624	50,240
Non-Affiliated IGFR	3,567	3,427	9,346	8,921	304	288
Indian	16,500	16,500	16,365	22,974	5,150	5,150
Total Area Acreage	77,979	75,579	69,428	73,636	58,078	55,678

IGFR = Irrigation Grandfathered Right

IV. Groundwater Conditions In 1985

Groundwater conditions in the Pinal AMA in 1985, the starting year for model simulations, are shown in Figures 2 to 5. The depth to water in the Upper Alluvial Unit (UAU), otherwise designated as Layer One, is shown in Figure 2. Depths to water range from less than 150 feet in the Maricopa-Stanfield and North Eloy sub-areas, to over 400 feet in the South Eloy sub-area. Historically, the UAU has been the most productive aquifer in the Pinal AMA. However, by 1985 excessive groundwater pumpage had reduced the saturated thickness of the UAU to less than 100 feet in many areas, and completely dewatered the UAU in much of the Maricopa-Stanfield and North Eloy sub-areas (Figure 3).

As water levels and well yields declined in the UAU more groundwater was pumped from the less productive deeper aquifers of the Maricopa-Stanfield and Eloy sub-areas. The deeper alluvial units, the Middle Silt and Clay Unit and the Lower Conglomerate Unit are combined into a single layer in the groundwater model and are otherwise designated as Layer Two. By 1985 the depth to water in wells which are perforated primarily in Layer Two exceeded 600 feet in many parts of the Maricopa-Stanfield sub-area (Figure 5). The depth to water in Layer Two in the Eloy sub-areas ranged from less than 150 to over 500 feet. In response to declining water levels the ADWR, at the request of the Pinal AMA Groundwater Users Advisory Council, has established a groundwater conservation requirement which limits agricultural groundwater pumpage to the depth interval between land surface and 1000 feet below land surface. Groundwater stored in the interval from 1000 to 1200 feet below land surface is reserved for future municipal and industrial users. The remaining saturated thickness of Layer Two above the 1000 foot agricultural pumping limit in the year 1985 is shown in Figure 5. It is apparent that much of the Maricopa-Stanfield sub-area has less than 400 feet of saturated aquifer remaining which is available for agricultural irrigation purposes.

V. Total CAP (TCAP) Water Utilization Scenarios

The Management Objective

The total utilization of all available surface water resources is a key water management objective for the Pinal AMA. The major benefit derived from totally utilizing all available surface water resources is that groundwater overdrafts would be reduced, and the agricultural economy would be maintained for a longer time. Presumably, additional time should also provide agricultural water users with better economic options as they seek to convert their land to non-agricultural uses. For these reasons, the series of model simulations presented in this chapter represent projected water supply and demand scenarios under which the major irrigation districts in the Pinal AMA totally utilize their CAP surface water allotments.

General Water Use Assumptions

Several general assumptions are incorporated into the water demand and supply scenarios which are presented in this report. A major assumption simulated for all scenarios is that non-Indian agricultural efficiencies will increase from approximately 66 percent in 1989 to about 81 percent by the year 2000. Another assumption simulated in all scenarios is a 1,200 acre per year reduction in Irrigation Grandfathered Right (IGFR) acreage, and an increase of 6,609 cropped acres within the Pinal AMA for the Gila River Indian Community in the year 2000. It is also assumed that the San Carlos Irrigation Project's main canal system will be lined by the year 2000 (ADWR, 1991c).

The water demand and supply scenarios did not account for the annual export of approximately 30,000 acre-feet of groundwater out of the Eloy sub-basin by the City of Mesa. These exports are tentatively scheduled to begin in the year 2000, and their impact on the balance of the AMA water demand and supply will be analyzed in future model runs.

The scenarios also did not include future water supply augmentation projects in the Pinal AMA. Existing augmentation of water supplies in the Pinal AMA include the import of surface water, effluent reuse, and a small, artificial groundwater recharge project near Florence. Future augmentation in the AMA, which may include large scale artificial recharge with stormwater runoff and excess surface water, will also be analyzed in future model runs.

Another potential water demand and supply scenario which was not simulated was the dewatering of a copper ore body near Florence. Recently the Magma Copper Company purchased a large mining claim in the Florence area. In the future, the company plans to begin substantial groundwater pumping operations to dewater the ore body. This scenario will be analyzed in future model runs.

Water Demand and Supply Estimates

The water demand and supply scenarios which are presented in this report were developed from data supplied by the Pinal AMA, the U.S. Bureau of Reclamation (USBR), the San Carlos Irrigation Project (SCIP), and the U.S. Soil Conservation Service (USSCS). The methodologies utilized to estimate the various budget components of the water budgets are described in Table 2.

TABLE 2
DERIVATION OF WATER BUDGET DEMAND AND SUPPLY ESTIMATES AND SOURCES OF DATA

Demand Category	***Methodology***
Municipal	[1] Municipal Population x ([2] Gallons/Capita/Day x 365) = Municipal Demand
Industrial	[3] 1986 Industrial Use Rates Prorated for Future Population Growth = Industrial Demand
Irrigation: Non-Indian	[4] Non-Indian Acreage x ([5] Consumptive Use/ [6] Irrigation Efficiency) = Non-Indian Irrigation
Irrigation: Indian	[7] Indian Acreage x ([8] Consumptive Use/ [9] Irrigation Efficiency) = Indian Irrigation
Canal Loss: ET	[10] Canal Surface Area (wetted) x [11](.062 FT^3/FT^2/Day x 365) x .2 = Evapotranspiration Losses[12]
Canal Loss: Seepage	[10] Canal Surface Area (wetted) x [11](.062 FT^3/FT^2/Day x 365) x .8 = Seepage Loss[13]
Supply Category	***Methodology***
Incidental Recharge	[14] .8 x [15]((.05 x Municipal Demand) + (Total Irrigation Demand x (1-Irrigation Efficiency)) + Canal Seepage Demand)
+/- Basin Underflow	[16] Flow Net Analysis [17] Model Results
CAP Supply	[18] 1989 Allocations and Future Allocation Estimates
SCIP Supply	[19] 56 Year Long Term Average 1930-1986
Santa Cruz River	[20] Reported Water Use in Red Rock area
Effluent	[21] 1986 Partial Reuse Rate, Which Increases With Population Growth

Data Sources

1 ADWR - Pinal AMA - SMP current and future population estimates.
2 ADWR - Pinal AMA - SMP GPCD rates.
3 ADWR - Pinal AMA - SMP 1986 Industrial Water Use Rates.
4 ADWR - Pinal AMA - SMP IGFR Acreage Total.
5 ADWR - Pinal AMA - SMP non-Indian Crop Consumptive Use.
6 ADWR - Pinal AMA - SMP non-Indian Irrigation Efficiency.
7 ADWR - Pinal AMA - SMP Indian Acreage Total.
8 ADWR - Pinal AMA - SMP Indian Crop Consumptive Use.
9 ADWR - Pinal AMA - SMP Indian Irrigation Efficiency.
10 ADWR - Hydrology Division - Canal Surface Area Estimate (Wetted).
11 USBR - CAP Water Supply Study - Canal Seepage and Evaporation Loss Rate Study - Tucson Aqueduct 1986 (USBR, 1986).
12 ADWR - Pinal AMA - ET Loss Estimates for SCIP for 1990-1999 based on Pinal AMA estimate. All CAP ET loss estimates and SCIP ET loss estimates for 2000-2025 based on described relation.
13 ADWR - Pinal AMA - Canal Seepage Estimates for SCIP for 1990-1999 based on Pinal AMA estimate. All CAP canal seepage estimates and SCIP canal seepage estimates for 2000-2025 based on described relation.
14 USSCS - Personal Communication from Dr. Herman Bouwer of USSCS to Pinal AMA staff concerning net infiltration from recharge (Bouwer, 1986).
15 ADWR - Pinal AMA - SMP Incidental Recharge Estimates.
16 ADWR - Hydrology Division - Flow Net Estimates of Underflow (Wickham and Corkhill, 1989).
17 ADWR - Hydrology Division - Groundwater Flow Model Underflows (Corkhill and Hill, 1990).
18 ADWR - Office of Colorado River Management - 1989 CAP allocation and future CAP water allocation estimates.
19 ADWR - Pinal AMA - Long term surface water availability estimate for SCIP 1930-1986.
20 ADWR - Pinal AMA - Reported Santa Cruz River water use estimate based on reported diversions by farmers.
21 ADWR - Pinal AMA - 1986 Partial reuse rate for effluent, which increases with population growth. It is assumed that all effluent will be reused after 2000.

100 Percent IGFR-Acreage

The model projections presented in this section simulate water supply and demand conditions assuming that 100 percent of the eligible IGFR acreage is farmed in 1989, and the total CAP allotment for the Pinal AMA is utilized.

The conceptual water budget for the 100 percent IGFR TCAP simulation is presented in Table 3. The water budget details the various components of supply and demand which impact the groundwater system of the Pinal AMA. The average annual conceptual groundwater overdraft simulated from 1989-1999 is 174,400 acre-feet per year. The average annual conceptual groundwater overdraft simulated from 2000 to 2025 is 213,400 acre-feet per year. The projected increase in groundwater overdraft is a function of many variables, however the major factor contributing to the increase is a projected decrease in CAP surface water availability.

The model output for the 100 percent IGFR TCAP simulation is presented in Figures 6 to 9. The projected depth to water in 2025 in Layer One is shown in Figure 6. The remaining saturated thickness of Layer One in the year 2025 is shown in Figure 7. The projected depth to water in 2025 for Layer Two is shown in Figure 8. The remaining Layer Two saturated thickness above the 1000 foot agricultural pumping limit in the year 2025 is shown in Figure 9.

TABLE 3 WATER BUDGET FOR PINAL AMA MODEL SIMULATION OF SMP WATER USE SCENARIO ASSUMING 100% IGFR ACREAGE AND TOTAL CAP UTILIZATION (Figures Rounded to Nearest 100 Acre-Feet/Year)		
Pinal AMA Summary Demand and Supply		
Water Demand	***1989-1999***	***2000-2025***
Municipal	13,700	16,200
Industrial	25,400	32,700
Irrigation: Non-Indian	1,210,500	901,500
Irrigation: Indian	175,700	208,900
Canal Losses:		
ET	28,500	21,400
Gross Seepage	92,500	30,400
Total Demand	**1,546,300**	**1,211,100**
Water Supply	***1989-1999***	***2000-2025***
Incidental Recharge	450,600	185,600
+/- Basin Underflow	45,700	45,700
Central Arizona Project	690,700	578,800
San Carlos Project	161,200	161,200
Other Surface Water:		
Santa Cruz River	20,000	20,000
Effluent Use	3,700	6,400
Total Supply	**1,371,900**	**997,700**
ANNUAL OVERDRAFT	**174,400**	**213,400**

TABLE 3 CONTINUED (Figures Rounded to Nearest 100 Acre-Feet/Year)						
Sub-Area Summary Demand and Supply						
	Area I		**Area II**		**Area III**	
Water Demand	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***
Municipal	1,600	2,000	9,600	11,200	2,500	3,000
Industrial	13,000	16,800	3,000	3,900	9,400	12,000
Irrigation: Non-Indian	436,300	337,400	405,700	301,300	368,500	262,800
Irrigation: Indian	75,000	75,000	82,200	115,400	18,500	18,500
Canal Losses:						
ET	700	600	26,300	19,300	1,500	1,500
Gross Canal Seepage	2,500	3,400	84,100	18,200	2,900	8,900
Total Demand	**529,100**	**435,200**	**610,900**	**469,300**	**406,300**	**306,600**
Water Supply						
Incidental Recharge	130,900	61,600	200,300	78,500	119,400	45,500
+/- Basin Underflow	24,600	24,600	-10,800	-10,800	31,900	31,900
Central Arizona Project	290,100	243,100	202,100	178,300	198,500	157,400
San Carlos Project	12,100	12,100	149,100	149,100	0	0
Other Surface Water:						
Santa Cruz River	0	0	0	0	20,000	20,000
Effluent Use	0	0	3,300	5,800	400	600
Total Supply	**457,700**	**341,400**	**544,000**	**400,900**	**370,300**	**255,400**
OVERDRAFT	**71,400**	**93,800**	**66,900**	**68,400**	**36,000**	**51,200**

Overdraft = Total Demand - Total Supply

80 Percent IGFR Acreage

The model projections simulated in this section simulate water supply and demand conditions assuming that 80 percent of the eligible IGFR acreage is farmed in 1989, and the total CAP allotment for the Pinal AMA is utilized.

The conceptual water budget for the 80 percent IGFR TCAP simulation is presented in Table 4. The total annual conceptual groundwater overdraft simulated from 1989 through 1999 is 2,400 acre-feet per year. The total annual conceptual groundwater overdraft simulated from 2000 to 2025 is 59,100 acre-feet per year. The large reduction in the projected groundwater overdraft for the 80 percent IGFR scenario compared with the 100 percent IGFR scenario is attributed to the retirement of agricultural acreage while maintaining maximum surface water use.

The model output for the 80 percent IGFR TCAP simulation is presented in Figures 10 to 13. Figure 10 shows the projected depth to water in Layer One for the year 2025. The remaining saturated thickness of Layer One in the year 2025 is shown in Figure 11. Figure 12 shows the projected Layer Two depth to water for the year 2025. The remaining Layer Two saturated thickness, above the 1000 foot agricultural pumping limit, in the year 2025 is shown in Figure 13.

TABLE 4 WATER BUDGET FOR PINAL AMA MODEL SIMULATION OF SMP WATER USE SCENARIO ASSUMING 80% IGFR ACREAGE AND TOTAL CAP UTILIZATION (Figures Rounded to Nearest 100 Acre-Feet/Year)		
Pinal AMA Summary Demand and Supply		
Water Demand	***1989-1999***	***2000-2025***
Municipal	13,700	16,200
Industrial	25,400	32,700
Irrigation: Non-Indian	968,400	721,100
Irrigation: Indian	175,700	208,900
Canal Losses:		
ET	28,500	21,400
Gross Seepage	92,500	30,400
Total Demand	**1,304,200**	**1,030,700**
Water Supply	***1989-1999***	***2000-2025***
Incidental Recharge	380,500	159,500
+/- Basin Underflow	45,700	45,700
Central Arizona Project	690,700	578,800
San Carlos Project	161,200	161,200
Other Surface Water:		
Santa Cruz River	20,000	20,000
Effluent Use	3,700	6,400
Total Demand	**1,301,800**	**971,600**
ANNUAL OVERDRAFT	**2,400**	**59,100**

TABLE 4 CONTINUED (Figures Rounded to Nearest 100 Acre-Feet/Year)						
Sub-Area Summary Demand and Supply						
	Area I		**Area II**		**Area III**	
Water Demand	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***
Municipal	1,600	2,000	9,600	11,200	2,500	3,000
Industrial	13,000	16,800	3,000	3,900	9,400	12,000
Irrigation: Non-Indian	349,000	269,900	324,600	241,000	294,800	210,200
Irrigation: Indian	75,000	75,000	82,200	115,400	18,500	18,500
Canal Losses:						
ET	700	600	26,300	19,300	1,500	1,500
Gross Canal Seepage	2,500	3,400	84,100	18,200	5,900	8,800
Total Demand	**441,800**	**367,700**	**529,800**	**409,000**	**332,600**	**254,000**
Water Supply						
Incidental Recharge	107,200	51,900	176,300	69,300	97,000	38,300
+/- Basin Underflow	24,600	24,600	-10,800	-10,800	31,900	31,900
Central Arizona Project	290,100	243,100	202,100	178,300	198,400	157,400
San Carlos Project	12,100	12,100	149,100	149,100	0	0
Other Surface Water:						
Santa Cruz River	0	0	0	0	20,000	20,000
Effluent Use	0	0	3,300	5,800	400	600
Total Supply	**434,000**	**331,700**	**520,000**	**391,700**	**347,800**	**248,200**
OVERDRAFT	7,800	36,000	9,800	17,300	-15,200	5,800

Overdraft = Total Demand-Total Supply

60 Percent IGFR Acreage

The model projections presented in this section simulate water supply and demand conditions assuming that 60 percent of the eligible IGFR acreage is farmed in 1989, and the total CAP allotment for the Pinal AMA is utilized.

The conceptual water budget for the 60 percent IGFR TCAP simulation is presented in Table 5. The total annual conceptual groundwater overdraft simulated from 1989 through 1999 is -169,600 acre-feet per year. The total annual conceptual groundwater overdraft simulated from 2000 to 2025 is -95,000 acre-feet per year. A negative overdraft represents an increase in the volume of groundwater in storage, and is calculated when the total water supply exceeds the total water demand. This condition exists for the 60 percent IGFR scenario due to the large reduction in non-Indian agricultural water demand while the total supply remains undiminished.

The model output for the 60 percent IGFR TCAP simulation is presented in Figures 14 to 17. Figure 14 shows the projected depth to water in Layer One for the year 2025. The remaining saturated thickness of Layer One in the year 2025 is shown in Figure 15. Figure 16 shows the projected Layer Two depth to water for the year 2025. The remaining Layer Two saturated thickness above the 1000 foot agricultural pumping limit in the year 2025 is shown in Figure 17.

TABLE 5 WATER BUDGET FOR PINAL AMA MODEL SIMULATION OF SMP WATER USE SCENARIO ASSUMING 60% IGFR CROPPED ACREAGE AND TOTAL CAP UTILIZATION (Figures Rounded to Nearest 100 Acre-Feet/Year)		
Pinal AMA Summary Demand and Supply		
Water Demand	***1989-1999***	***2000-2025***
Municipal	13,700	16,200
Industrial	25,400	32,700
Irrigation: Non-Indian	726,300	541,000
Irrigation: Indian	175,700	208,900
Canal Losses:		
ET	28,500	21,400
Gross Seepage	92,500	30,400
Total Demand	**1,062,100**	**850,600**
Water Supply	***1989-1999***	***2000-2025***
Incidental Recharge	310,400	133,500
+/- Basin Underflow	45,700	45,700
Central Arizona Project	690,700	578,800
San Carlos Project	161,200	161,200
Other Surface Water:		
Santa Cruz River	20,000	20,000
Effluent Use	3,700	6,400
Total Demand	**1,231,700**	**945,600**
ANNUAL OVERDRAFT	**-169,600**	**-95,000**

TABLE 5 CONTINUED (Figures Rounded to Nearest 100 Acre-Feet/Year)						
Sub-Area Summary Demand and Supply						
	Area I		**Area II**		**Area III**	
Water Demand	**1989-1999**	**2000-2025**	**1989-1999**	**2000-2025**	**1989-1999**	**2000-2025**
Municipal	1,600	2,000	9,600	11,200	2,500	3,000
Industrial	13,000	16,800	3,000	3,900	9,400	12,000
Irrigation: Non-Indian	261,800	202,500	243,400	180,800	221,100	157,700
Irrigation: Indian	75,000	75,000	82,200	115,400	18,500	18,500
Canal Losses:						
ET	700	600	26,300	19,300	1,500	1,500
Gross Canal Seepage	2,500	3,400	84,100	18,200	5,900	8,800
Total Demand	**354,600**	**300,300**	**448,600**	**348,800**	**258,900**	**201,500**
Water Supply						
Incidental Recharge	83,500	42,200	152,300	60,100	74,600	31,200
+/-Basin Underflow	24,600	24,600	-10,800	-10,800	31,900	31,900
Central Arizona Project	290,100	243,100	202,100	178,300	198,500	157,400
San Carlos Project	12,100	12,100	149,100	149,100	0	0
Other Surface Water:						
Santa Cruz River	0	0	0	0	20,000	20,000
Effluent Use	0	0	3,300	5,800	400	600
Total Supply	**410,300**	**322,000**	**496,000**	**382,500**	**325,400**	**241,100**
OVERDRAFT	**-55,700**	**-21,800**	**-47,400**	**-33,700**	**-66,500**	**-39,600**

Overdraft = Total Demand - Total Supply

VI. Partial CAP (PCAP) Utilization

Groundwater Pumpage vs CAP Utilization

Hydroelectric power is available and inexpensive in the Pinal AMA. At this time it is less costly for end users to pump groundwater than purchase surface water from the CAP. As a consequence some of the major irrigation districts do not fully utilize their CAP allotments. Economically this makes sense, but the current benefits must be weighed against the negative long-term effects of under-utilization. The districts may eventually lose some of their present

CAP allocations. In addition, it has been demonstrated that utilization of surface water, rather than groundwater, is the only way to reduce groundwater overdraft while maintaining the current level of agricultural activity. For these reasons the model simulation presented in this chapter represents projected supply and demand conditions under which the major irrigation districts in the Pinal AMA partially utilize their CAP allotments. Only the 60 percent IGFR acreage PCAP scenario is presented because it has been determined that the irrigation districts would probably fully utilize their CAP allotments if substantially more acreage were farmed, and therefore the 80 percent and 100 percent TCAP simulations which have already been presented represent those conditions.

60 Percent IGFR - Acreage

The model projections presented in this section are probably most representative of the actual water supply and demand conditions which currently exist in the Pinal AMA. The amount of land currently farmed in the Pinal AMA is about 60 percent of the total eligible IGFR acreage. To the present time the major irrigation districts have not fully utilized their CAP allotments.

The conceptual water budget for the 60 percent IGFR PCAP simulation is presented in Table 6. The total annual conceptual overdraft simulated from 1989 through 1999 is -53,400 acre-feet per year. The total annual conceptual groundwater overdraft simulated from 2000 to 2025 is 33,500 acre-feet per year. Over the 36 year period from 1989 to 2025 the cumulative projected overdraft is about 250,000 acre-feet. By comparison, the cumulative projected overdraft for the 60 percent TCAP scenario is about -4,245,000 acre-feet. It is clear from this comparison that under today's land use conditions groundwater overdraft can be slowed, or reversed by fully utilizing CAP allotments.

The model output for the 60 percent IGFR PCAP simulation is presented in Figures 18 to 21. The projected depth to water in 2025 in Layer One is shown in Figure 18. The remaining saturated thickness of Layer One in the year 2025 is shown in Figure 19. The projected depth to water in 2025 for model Layer Two is shown in Figure 20. The remaining Layer Two saturated thickness above the 1000 foot agricultural pumping limit in the year 2025 is shown in Figure 21.

TABLE 6 WATER BUDGET FOR PINAL AMA MODEL SIMULATION OF SMP WATER USE SCENARIO ASSUMING 60% IGFR ACREAGE AND PARTIAL CAP UTILIZATION (Figures Rounded to Nearest 100 Acre-Feet/Year)		
Pinal AMA Summary Demand and Supply		
Water Demand	***1989-1999***	***2000-2025***
Municipal	13,700	16,200
Industrial	25,400	32,700
Irrigation: Non-Indian	726,300	541,000
Irrigation: Indian	175,700	208,900
Canal Losses:		
ET	28,600	21,400
Gross Seepage	92,500	30,500
Total Demand	**1,062,200**	**850,700**
Water Supply	***1989-1999***	***2000-2025***
Incidental Recharge	310,400	133,500
$^+$/- Basin Underflow	45,700	45,700
Central Arizona Project	574,600	421,000
San Carlos Project	161,200	161,200
Other Surface Water:		
Santa Cruz River	20,000	20,000
Effluent Use	3,700	6,400
Total Supply	**1,115,600**	**787,800**
ANNUAL OVERDRAFT	**-53,400**	**33,500**

TABLE 6 CONTINUED (Figures Rounded to Nearest 100 Acre-Feet/Year)						
Sub-Area Summary Demand and Supply						
	Area I		**Area II**		**Area III**	
Water Demand	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***	***1989-1999***	***2000-2025***
Municipal	1,600	2,000	9,600	11,200	2,500	3,000
Industrial	13,000	16,800	3,000	3,900	9,400	12,000
Irrigation: Non-Indian	261,800	202,500	243,400	180,800	221,100	157,700
Irrigation: Indian	75,000	75,000	82,200	115,400	18,500	18,500
Canal Losses:						
ET	700	600	26,400	19,300	1,500	1,500
Gross Canal Seepage	2,500	3,400	84,100	18,200	5,900	8,900
Total Demand	**354,600**	**300,300**	**448,700**	**348,800**	**258,900**	**201,600**
Water Supply						
Incidental Recharge	83,500	42,200	152,300	60,100	74,600	31,200
+/- Basin Underflow	24,600	24,600	-10,800	-10,800	31,900	31,900
Central Arizona Project	223,100	178,700	202,100	178,300	149,400	93,400
San Carlos Project	12,100	12,100	149,100	149,100	0	0
Other Surface Water:						
Santa Cruz River	0	0	0	0	20,000	20,000
Effluent Use	0	0	3,300	5,800	400	600
Total Supply	**343,300**	**257,600**	**496,000**	**382,500**	**276,300**	**177,100**
OVERDRAFT	**11,300**	**42,700**	**-47,300**	**-33,700**	**-17,400**	**24,500**

Overdraft = Total Demand - Total Supply

VII. Discussion of Model Results

The results of the model simulations provide an informative picture of potential groundwater conditions in the year 2025. The results of the 80 percent and 100 percent IGFR simulations are provided to show conditions which could occur if there were a substantial increase in agricultural activity. Although recovery from todays 60 percent IGFR use level is possible, it seems more likely that todays level of non-Indian agricultural activity represents a maximum which will probably decrease with time.

The results of the 60 percent TCAP and PCAP simulations are the most probable conditions which have been simulated, presuming all the underlying assumptions of the conceptual water budgets hold true. The PCAP results indicate that the depth to water will continue to increase in the Maricopa-Stanfield sub-area (Figures 2, 4, 18, 20). The PCAP results predict that there will be less than 300 feet of saturated thickness above the 1000 foot agricultural pumping limit in the year 2025 in much of the Maricopa-Stanfield sub-area (Figure 21). The PCAP results also predict shallower depths to water in most of the Eloy sub-area (Figure 20). The TCAP results generally predict water level stabilization and recovery throughout most of the model area (Figures 14 and 16).

It is apparent that safe yield conditions could exist if all of the 60 percent TCAP assumptions were to hold true. However, the reality of water use trends in the Pinal AMA is more characteristic of the PCAP scenario. Under PCAP conditions much of the Maricopa-Stanfield sub-area will be faced with curtailing agricultural pumping of groundwater by the year 2025.

VIII. Summary and Conclusions

Groundwater conditions through the year 2025 have been simulated using the Pinal AMA Regional Groundwater Flow Model. Two scenarios were developed to simulate these potential water supply and demand conditions: 1) total utilization of projected annual CAP surface water supplies for non-Indian irrigation when either 60, 80 or 100 percent of all IGFR acreage is irrigated (TCAP scenario), and 2) partial utilization of CAP, with 60 percent of all IGFR acreage irrigated (PCAP scenario).

The PCAP scenario is based on the assumption that the major irrigation districts will not fully utilize their CAP allotments. The projected PCAP conceptual groundwater overdraft is 978,000 acre-feet for the period 1989-2025. Under PCAP conditions groundwater levels are predicted to decline in the Maricopa-Stanfield sub-area. By 2025 the model predictions indicate that the depth to water will near the 1000 foot agricultural limit in many parts of the Maricopa-Stanfield sub-area. The PCAP scenario is probably most representative of current conditions, and emphasizes the need to maximize the use of surface water in order to maintain the agricultural economy.

The TCAP scenario is based on the assumption that the major irrigation districts fully utilize their CAP allotments. The projected TCAP conceptual groundwater overdraft is –4,245,000 acre-feet for the period 1989-2025. Under TCAP conditions groundwater levels are predicted to stabilize or rise in most of the Pinal AMA. The TCAP scenario simulates groundwater consumption at less than safe yield. While it seems unlikely that the Pinal AMA will actually achieve this level of groundwater consumption it demonstrates the effect of reducing agricultural acreage while maximizing the use of all available surface water.

The groundwater modeling effort has provided a wealth of information concerning the groundwater flow system of the Pinal AMA. The groundwater model has demonstrated its usefulness in identifying potential groundwater problem areas. It is recognized that the groundwater model can be improved, and our knowledge of future water use conditions will no doubt also improve with time. Therefore, it is recommended that the model be updated and maintained on a regular basis to insure its future usefulness. In conclusion, the model has demonstrated that groundwater conditions in the Pinal AMA are not static, and affirms the need to actively manage the groundwater resource.

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X. Figures